TECHNICAL REPORT NO. 74-23

DESIGN AND TEST OF AN AIR CUSHION FIELD DOLLY FOR UH/AH HELICOPTERS

TASK 05-M-72

By

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March 1974

Final Report

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The need to move helicopters from their landing point to a place of concealment, or more appropriate parking spot, was first stated by the 4th Armored Division in Europe.

Since 1970, USA Land Warfare Laboratory has been involved in a number of tasks associated with the ground movement of helicopters. These have involved hardware designed and built to demonstrate both the potential and problems of
CON'T

20. ABSTRACT (CON'T)

various means of handling skid-mounted helicopters in rough terrain. The Air Cushion Field Dolly is but one of these pieces of hardware.

The Air Cushion Field Dolly is an air-supported dolly without forward propulsion. Tests indicated that the dolly operated as intended up to helicopter gross weights of 7500 pounds. At helicopter gross weights above 7500 pounds the dolly operated satisfactorily on smooth ground, but required excessive drawbar pull on rough terrain. Although the dolly was capable of performing the desired mission, it was considered that it was too large and too complicated, relatively, for troop use in a forward area.

AD-779386

PREFACE

The need to move helicopters from their landing point to a place of concealment or more appropriate parking spot was first conveyed to US Army Land Warfare Laboratory (LWL) in November 1970 by the 4th Armored Division in Europe through an LWL Liaison Team. At that time, LWL initiated a study into the feasibility of moving skid-mounted helicopters in rough terrain. The ground rules for the study were laid out in the form of in-house generated military characteristics which appear in this report as Appendix A. These military characteristics have been used as a guide for all LWL tasks relative to helicopter moving.

The initial study was conducted for LWL by the Dynasciences Corp. under a services contract arrangement. The study results are reported in Reference 1[1]. Although ground effects devices were considered at that time, they were not pursued due to a desire to develop an unpowered device.

In November 1971, the Grumman Aerospace Corporation, Bethpage, NY submitted an unsolicited proposal to Office, Chief of Research and Development (OCRD) for an "Utility Helicopter Air Cushion Field Dolly" (Huey Mover). The proposal was accepted, and contract negotiations for a prototype unit were entered into. Sufficient interest was raised by the proposal, that when an impasse was reached in the negotiations, OCRD requested that LWL build a test unit.

LWL then proceeded to design, fabricate, and test an air cushion field dolly. The design philosophy was to follow the basic ground rules outlined in the military characteristics, with a minimum of complexity consistent with a reasonable probability of meeting the design goals.

[1]"Feasibility Study of Designing an Off-Runway Handling Gear for Skid-Mounted Helicopters", DCR-327, April 1971, by K. Korsak and E. Kisielowski.

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DESIGN

General

In keeping with the design philosophy, a fixed geometry plenum chamber was chosen as the basic design. The chamber is divided into four equal areas to provide a degree of stability, and a 15" high flexible skirt added to increase effective obstacle clearance height. Figure 1 shows the basic configuration, and the size of the dolly relative to a UH-1 helicopter. The primary structure is an air inflated torus with a major diameter of 20 feet, and a minor diameter of 20 inches. A secondary aluminum structure contains all of the operating hardware, and supports the helicopter. The dolly provides lift only and horizontal propulsion is provided from some external source. Figure 2 shows the assembled dolly with a UH-1B on board, and a jeep as a tow vehicle. The torus is inflated, but the dolly is not on an air cushion.

Specific

The dolly was sized to support UH/AH helicopters up to gross weights of 10,000 pounds. The area was determined as a compromise between the desire for a minimum width for tree clearance, the necessity for adequate lateral stability, the pressure limitations of available axial flow fans, and a desire to minimize structural complexity. It was decided that, among the simple shapes that lend themselves to air inflation, a circular shape was best suited for this application. Considering a structural design weight of 1000 pounds, a helicopter weight of 10,000 pounds, and a nominal fan pressure capability of eight inches of water, we arrive at a nominal diameter of 20 feet. This is compatible with helicopter dimensions, and provides adequate stability in all directions.

Two lift fans are used in order to minimize the solid structure thickness, which facilitates loading the helicopter. Figure 3 is a drawing of the fan used (it was used without the diffuser), and Figure 4 shows its performance characteristics. Each fan provides air to two of the four plenum quadrants. The fans are belt-driven by a Kiekhaefer Aeromarine Model 440 2-cycle air-cooled gasoline engine. A curve of its performance characteristics is shown in Figure 5. The fans are driven at the engine speed of 6500 to 7000 rpm.

In order to make it transportable by UH-1 helicopter or standard Army trucks, the dolly was designed to be disassembled and assembled in the field. It is broken into eight major component parts: (1) the center structure containing the lift fans; (2) the engine section containing the engine, its controls and fuel tank, and the torus inflation pump; (3) the torus and diaphragm; (4) a section identical to the engine section but containing no operating machinery; and (5), (6), (7), and (8) support ramps. Figure 6 shows these component parts laid out ready for assembly. Assembly is effected by pinning the structure together with ball lock type pins. Figure 7 shows the structure assembled and ready for loading.

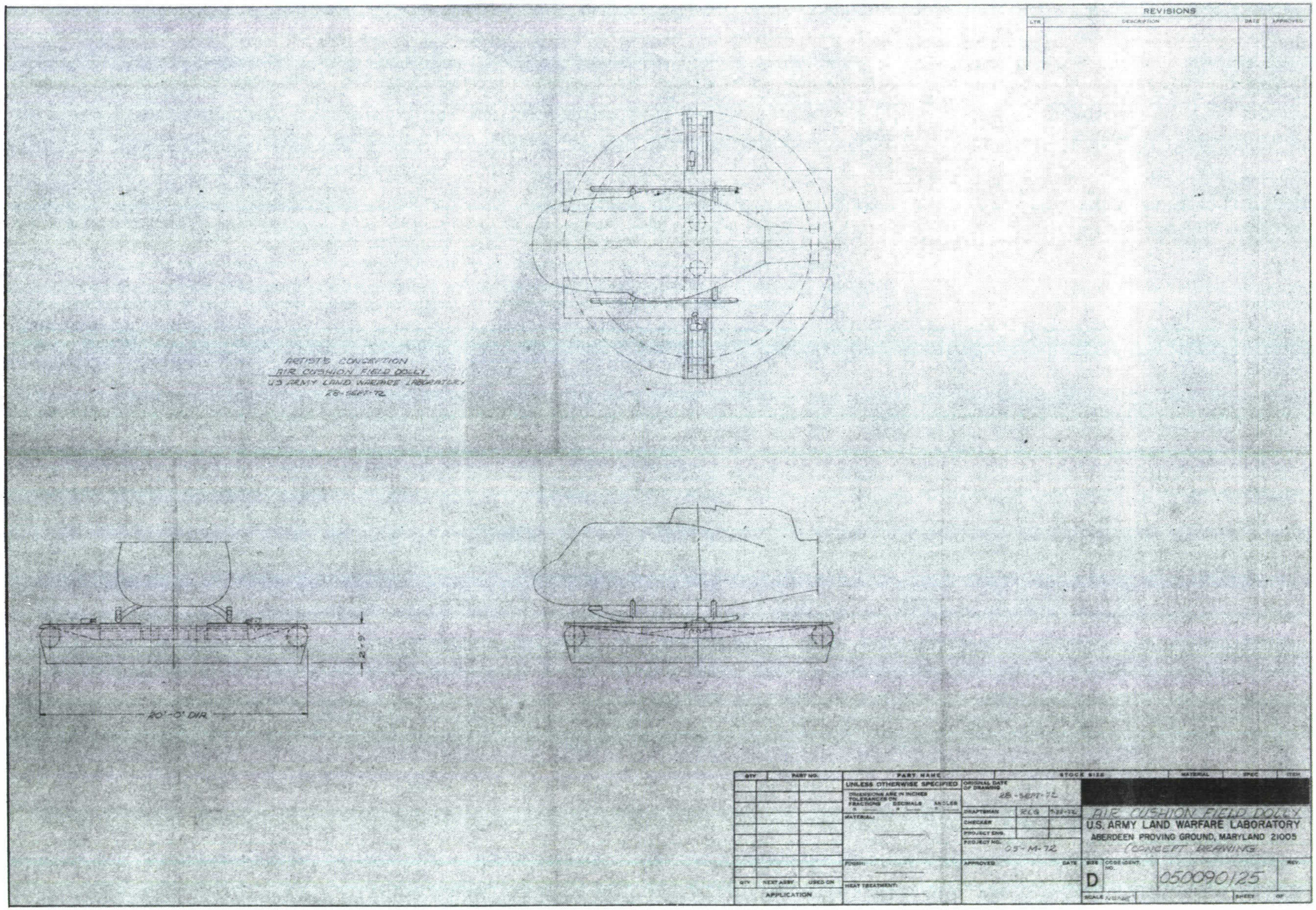

Figure 1. Basic Configuration Drawing

Figure 2. UH-1B on Dolly, Jeep Tow Vehicle

FAN

Part Number — 500702 - 4950
Model Number — AVR 135 - 52D2112
Design Rating CFM — 7,300
Pressure Inches W.G. — 4.9

Weight (Pounds) — 10.3
Construction — Magnesium
Performance Curve — C-4356
Design Specification — Military

Horsepower — 10.0
Speed R.P.M. — 7,070

OIL COOLER FAN SIKORSKY CH-53A (SEA STALLION)

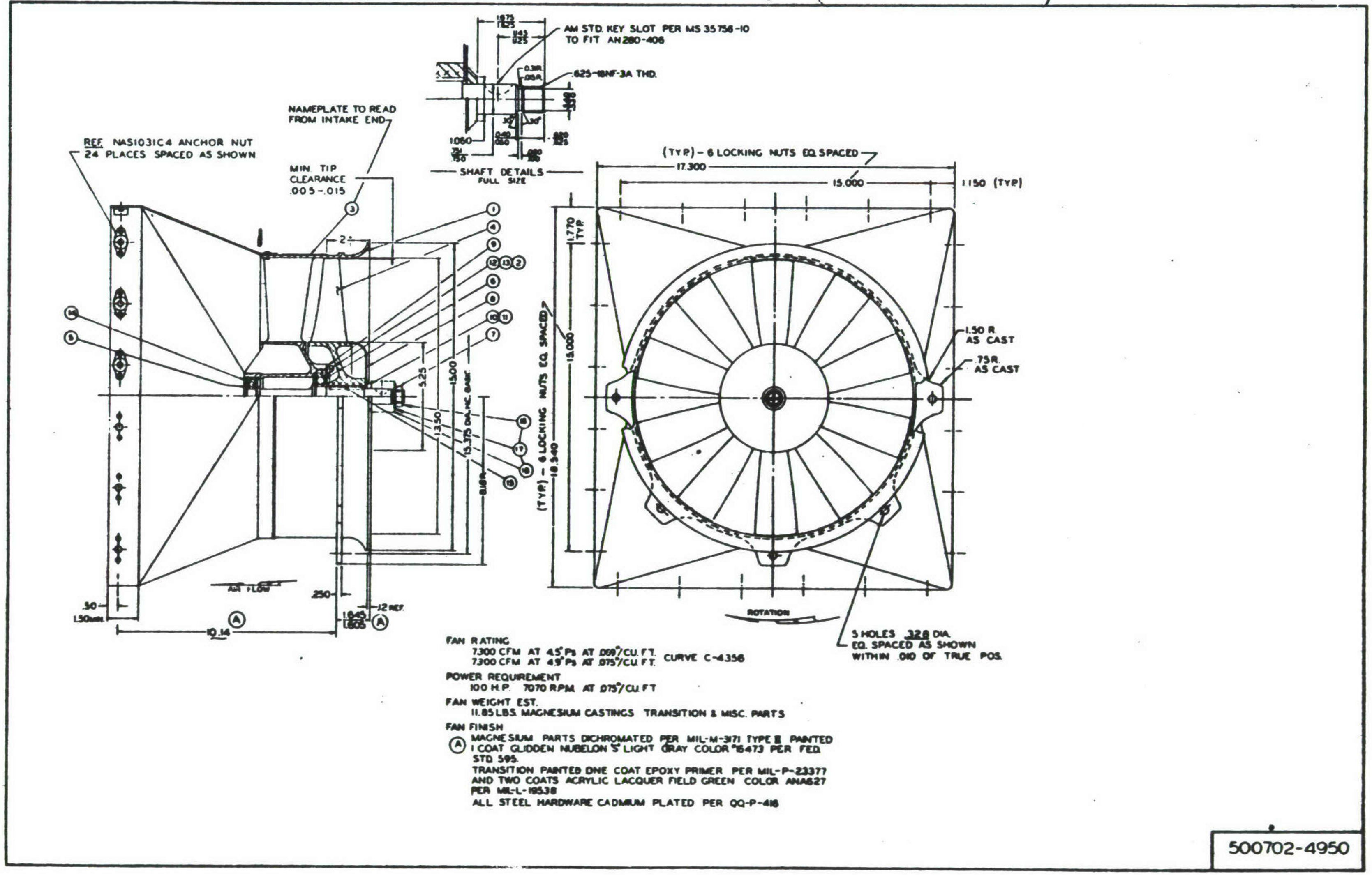

Figure 3. Lift Fan Drawing

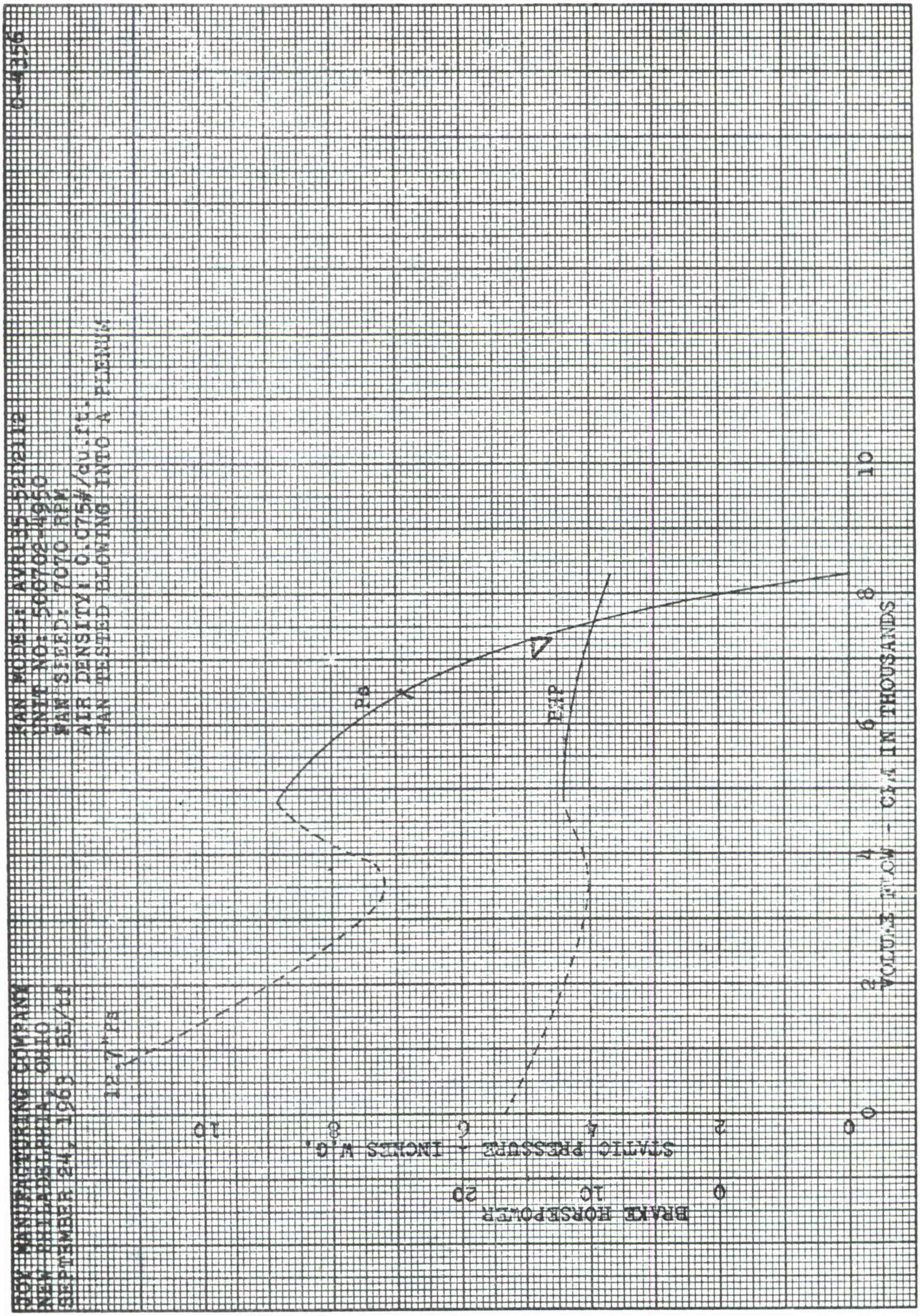

Figure 4. Lift Fan Performance

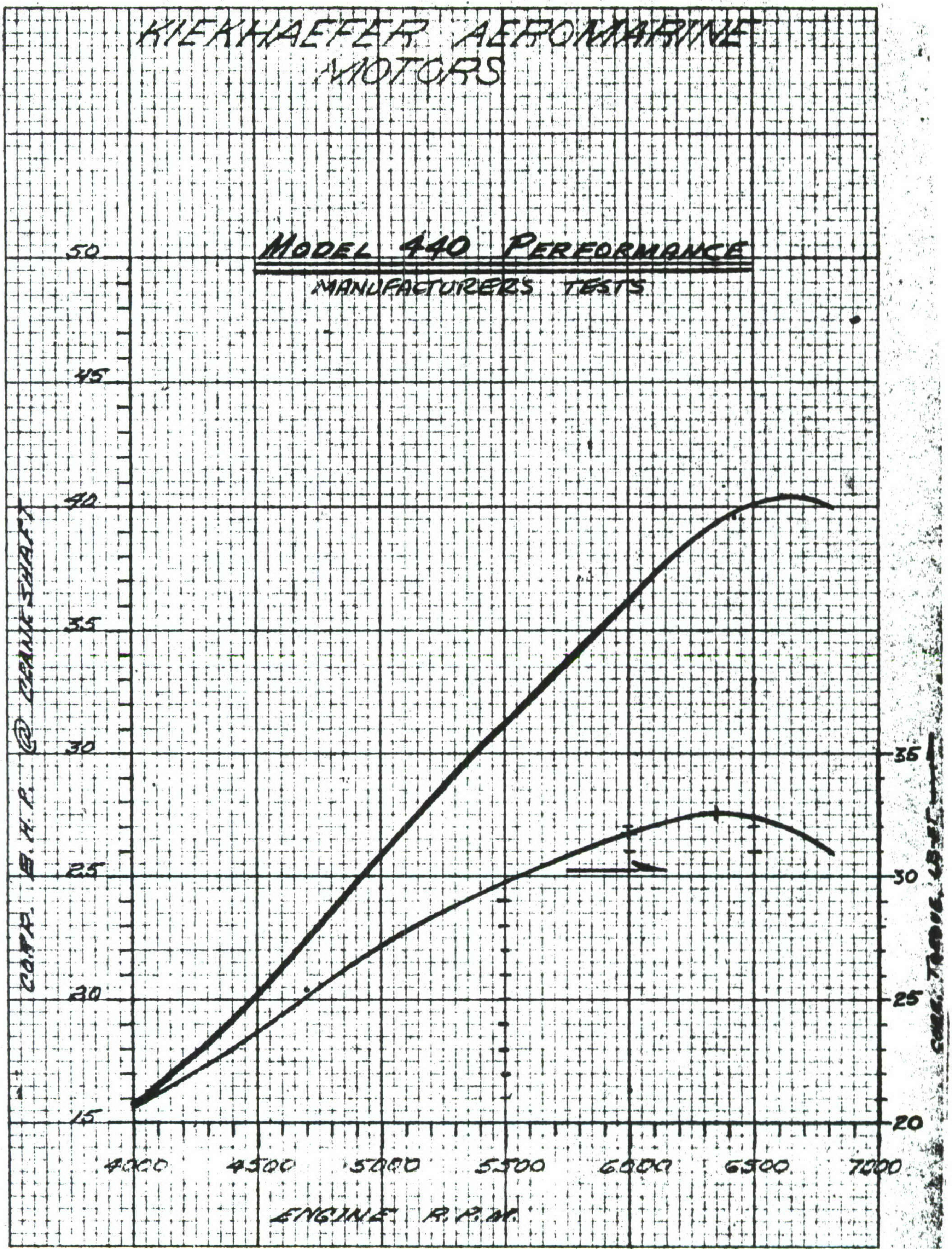

Figure 5. Kiekhaefer Aeromarine Model 440 Performance

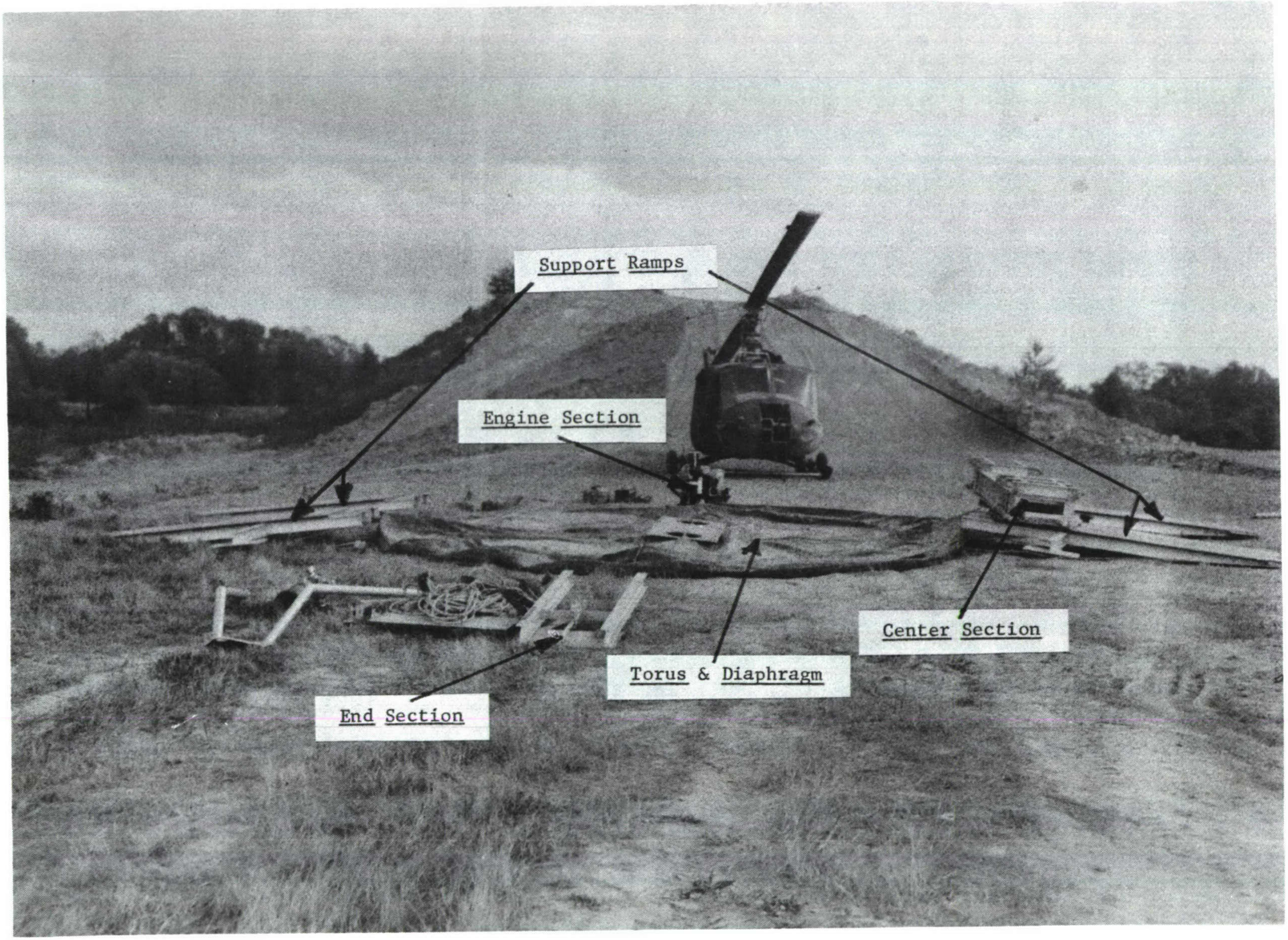

Figure 6. Dolly Component Parts

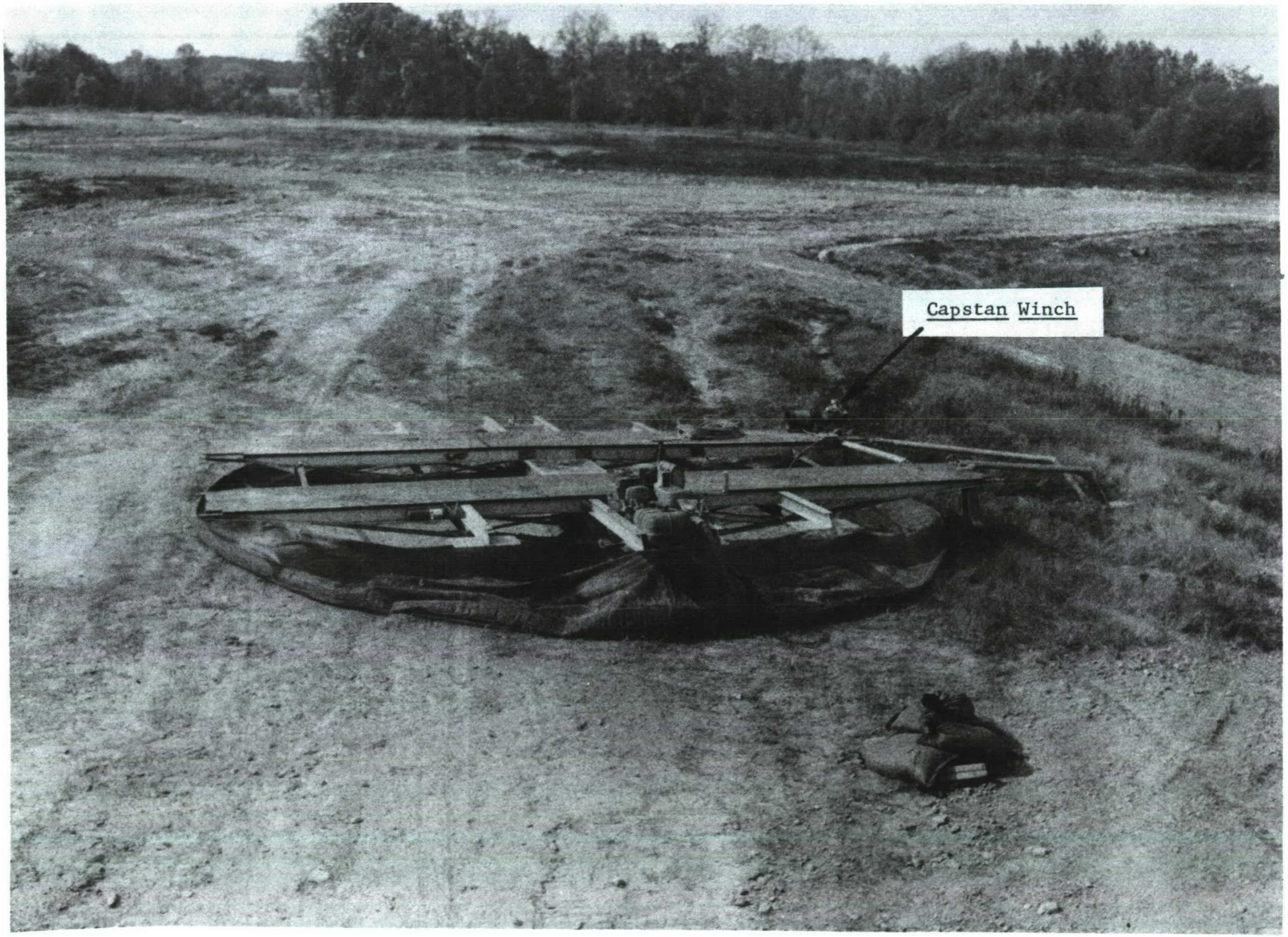

Figure 7. Assembled Dolly

The basic structure was fabricated primarily from material on hand at LWL, and as such does not represent a minimum weight. It is estimated that a weight saving of approximately 1000 pounds, out of an existing weight of 2300 pounds, could be made in an item designed for production.

A simple means of loading and unloading a helicopter was a major design consideration. It was considered that no changes were to be made to the helicopter, and that the loading procedure must not apply loads to the helicopter in any unusual manner. It was also considered that special equipment, and the need for attaching and detaching ramps, rollers, etc., should be kept to a minimum. As a consequence, the supporting structure was designed to act as a ramp also. Loading is effected by tilting the structure down see-saw fashion, and pulling the helicopter up the ramp on its standard ground handling wheels until the see-saw balances. Pads to prevent going past a level position are provided on the ends of the ramp. Figure 8 shows a helicopter being loaded on the dolly. The helicopter is pulled up the ramp by means of a small engine-driven capstan winch mounted on the corner of one of the ramps. It can be seen in Figure 7. The helicopter can be loaded either nose or tail first.

Since loading and unloading require deflation of the torus, provisions for inflation are built into the engine section. A vane pump, capable of 150 cfm at a pressure of 5 psi, is belt driven through a clutch arrangement from the engine. The torus is filled to an operating pressure of 5 psi in approximately one minute. Pressure is maintained in the torus by a check valve.

Figure 8. Loading Procedure

TESTING

Tests were conducted by LWL, TECOM and MASSTER. Since the intent of the program was to demonstrate potential and problems associated with handling skid mounted helicopters in rough terrain, the tests were mostly qualitative in nature. Quantitative testing was limited to determining the load capability of the dolly, and verifying the pressure output of the lift fans. The load capability was determined by adding ballast in increments to a helicopter of known weight, loading the helicopter onto the dolly, and then pulling the combination over moderately rough terrain with an M151 Jeep. Fan pressure output was monitored in the plenum by means of a water manometer. Figure 9 shows the test helicopter on the dolly. In this case, moderately rough terrain is defined as relatively level ground with gulleys or rises of one foot, and with slopes not exceeding 20 percent. It was found that, for these conditions, a helicopter gross weight of 7500 pounds was a practical limit for towing with a jeep. Tests were continued, however, up to a helicopter gross weight of 10,000 pounds. The dolly could be towed with a 2-1/2 ton truck with this load, but dragged frequently on ground contours. On smooth ground the dolly could be manhandled at all gross weight tested, provided that the load was balanced. All tests indicated that it was not difficult to balance the dolly within limits that could be corrected by the weight of one man.

Stability of the dolly was adequate for all conditions. Four segments in the plenum are sufficient. It was noted, however, that for very smooth ground (a concrete pad), and a range of helicopter gross weights from 5000 to 7500 pounds, the dolly exhibited a low frequency vertical instability of 1 to 2 cycles per second. It was found that this could be eliminated simply by creating an inbalance in the dolly such that the air gap was not the same all around the periphery.

Control of the dolly was just about what would be expected of a device with no sense of direction; it simply sought the lowest level. Control was easily effected, however, by noting the lay-of-the-land, and by not attempting to move cross-slope.

As with any air supported vehicle, the dolly depends on a constant flow of air escaping all around its periphery. The velocity and quantity of air in this instance are sufficient to blow loose grass and dust up to operator level, but did not blow small gravel above pants cuff height. Operation in dusty conditions require the operator to wear both goggles and a respirator. It should be noted, however, that severe dust problems were an exception rather than a rule in the test areas. The test areas included: a concrete pad, a crushed gravel road-way, a mowed field, an unmowed field, a very dusty tank test course, and the edges of a small swamp. Only on the tank test course was the dust a problem.

A demonstration of the Air Cushion Field Dolly was conducted at MASSTER, (Modern Army Selected Systems Test, Evaluation, and Review), Ft. Hood, Texas in December 1973. The dolly was assembled, disassembled, loaded into a 2-1/2 ton truck, and operated over a variety of terrain conditions by US Army personnel under the supervision of the LWL task officer. A MASSTER

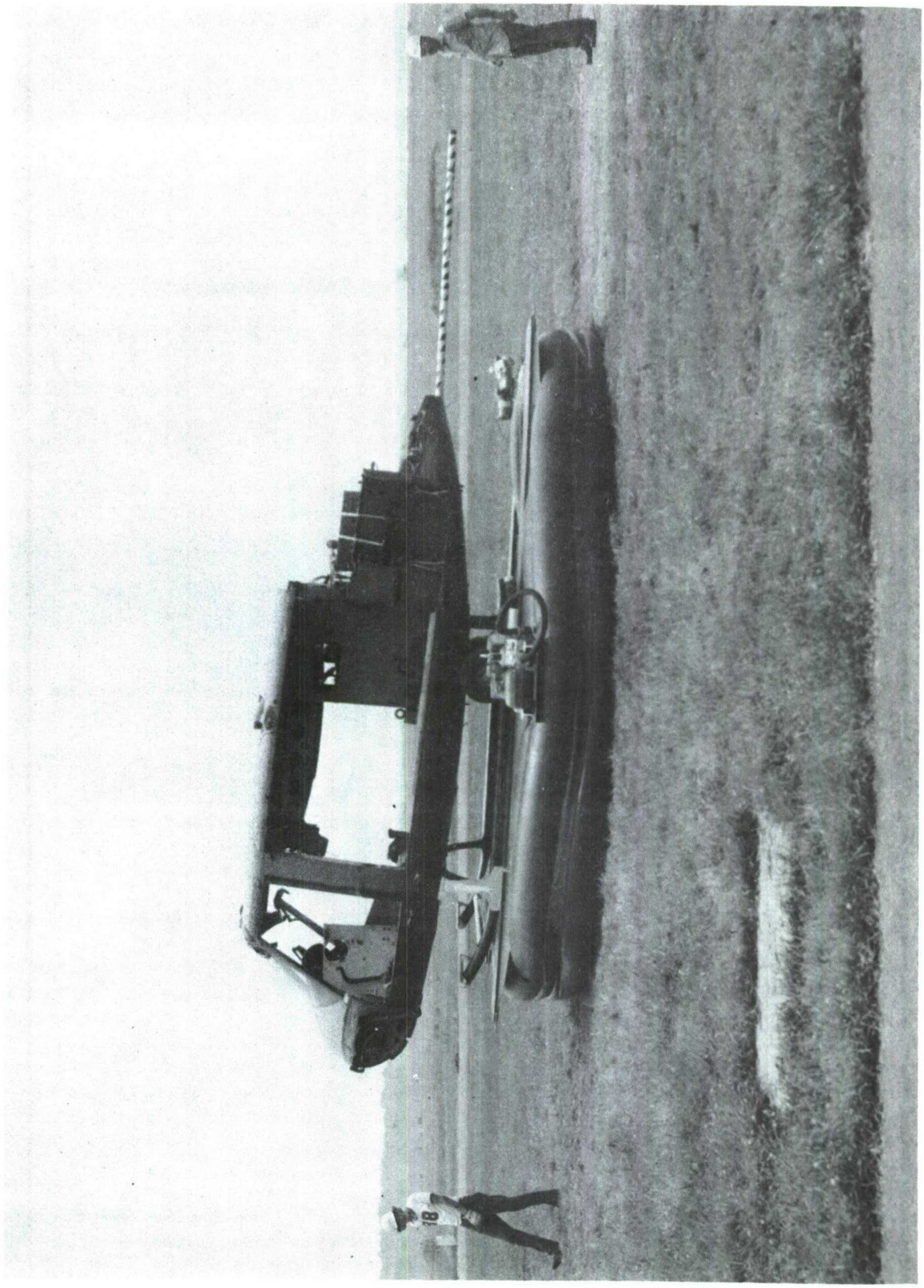

Figure 9. Load Limit Test

test report will be published at the conclusion of the MASSTER tests. This report will include a number of other means of moving helicopters in rough terrain. Discussions with the MASSTER test officer indicate that MASSTER conclusions will be as follows:

1. The Air Cushion Field Dolly is capable of handling UH/AH helicopters in terrain conditions most likely to be encountered in the field.

2. The deficiencies noted, mainly noise and weight, are engineering deficiencies which could be alleviated in a future model.

3. The size and relative complexity of the device preclude its practical use by troops in forward areas.

APPENDIX A

21 December 1970

MILITARY CHARACTERISTICS FOR FEASIBILITY STUDY FOR ROUGH TERRAIN GROUND HANDLING SYSTEM FOR HELICOPTERS

1. REQUIREMENT:

a. Provide U.S. Army units with the capability of pushing or pulling helicopters across rough terrain and maneuvering them rapidly into and out of tree lines so that they could be easily concealed from aerial view and camouflaged.

b. Source of Requirement: USALWL Briefing Team to USAREUR (LTC Romig and Mr. Shira), 4th Armored Division, November 1970.

2. OPERATIONAL & ORGANIZATIONAL CONCEPTS:

a. Operational Concept: Aviation units would use this item as part of their ground support equipment. It would be transported to the site either by vehicle or by aircraft.

b. Organizational Concept: It is envisioned that this item would be available through normal supply channels for the class of supply and would be issued on a basis of one per certain number of aircraft or size of unit.

3. JUSTIFICATION & PRIORITY:

a. Reason for the Requirement: The Ground Handling Kit currently used consists of wheels which raise the skids. The system can only be used with difficulty on rough terrain since there is very little ground clearance and a high ground pressure. A rough terrain system which would permit rapid easy movement of helicopters around on rough terrain and into and out of tree lines does not exist.

b. Priority for Requirement: Priority Grouping III.

4. CHARACTERISTICS:

a. Performance Characteristics:

(1) (Essential) The device should be rugged and capable of moving a helicopter safely over rough terrain to include wet and dry plowed ground and grass grown areas (minimum cone index 40) and to negotiate 15 inch deep ditches or holes without a requirement for digging or disturbing the soil.

4. CHARACTERISTICS: (Cont'd)

(2) Number of major components: (Desired) 1.

(3) Maximum weight: (Essential) Must be capable of being loaded/off loaded from a vehicle by two to four men by manpower alone.

(4) Maximum Size/Transportability: (Essential) Must require a minimum of space to transport/store and be transportable on a 3/4 ton truck and a UH-1 helicopter as an interior and exterior load. (Desired) Items should have the capability of being nested or stacked when more than one is transported at a time.

(5) Environmental Requirement: (Essential) Climatic Categories 2 thru 7 (AR 70-38).

(6) Paradrop: (Desired) Yes.

(7) Maximum Assemble/Disassemble Time:

(a) Preparation for use from transported mode by two men, (Essential) 15 minutes.

(b) Loading/Unloading helicopter by two men, (Essential) 1 minute; (Desired) ½ minute.

(8) Performance Requirements:

(a) (Essential) Must be capable of moving the following helicopters: UH-1B, UH-1C, UH-1D, UH-1H, OH-58A, OH-6, AH-1G with lateral stability.

(b) (Essential) Require no more than the draw-bar pull of a ¼ ton vehicle to move a helicopter with it and be capable of being moved by vehicles up to and including 2½ ton in size; (Desired) 2 men.

(c) (Essential) Not place side loads on the skids of the helicopters being moved.

(d) (Essential) Must be capable of being maneuvered while being moved in order to guide the helicopter between trees and around obstacles.

b. Maintenance Concept: (Essential) Require little or no maintenance.

c. Human Engineering Characteristics: (Essential) Require no special training and be safe in operation in accordance with AR 602-1, dtd 4 March 1968 and AR 385-16, dtd 11 February 1967.

MC'S FOR FEASIBILITY STUDY FOR ROUGH TERRAIN GROUND HANDLING SYSTEM FOR HELICOPTERS — 21 December 1970

4. CHARACTERISTICS: (Cont'd)

d. Priority of Characteristics: Performance, size, weight.

5. PERSONNEL CONSIDERATIONS: Introduction of this item into the Army inventory will require no additional spaces in TO&E of tactical units.

DATE 22 Dec 1970

APPROVED: Alexander Johnston III for MIKE ELLIS
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